THE TESTS FOR INVOLVEMENT OF THE LABYRINTH IN SUPPURATIVE MIDDLE EAR PROCESSES.

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Within the last two years Barany of Vienna, after much painstaking research work, has devised a series of tests by which the involvement of the labyrinth in suppurative middle ear and mastoid conditions may be ascertained. These tests are based upon the normal reflex reactions of the semicircular canals in producing nystagmus of the eyes: the findings may show the reactions normal, in which event involvement is ruled out; or that they are impaired, lost, heightened or abnormally produced, in which event the condition of the organ, considered with the other functional reactions of hearing and the objective symptoms shown, may be quite accurately ascertained.

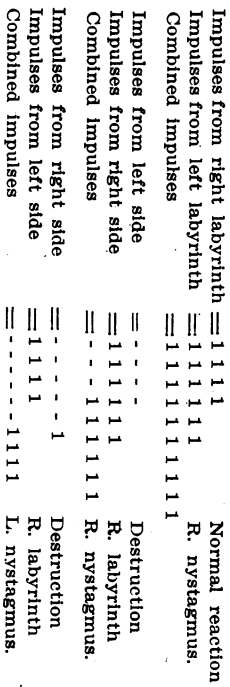
Purkinje, in 1825, first discovered nystagmus, but as he observed it in cases of insanity, thought it only occurred in and was one of the symptoms of that condition. Flourens, about the same time, experimenting on pigeons, discovered that when one of their semicircular canals was destroyed, the bird reacted with somersaults in the plane of the destroyed canal, and this gave the first clew to the part played in orientation by this organ; Goltz, in 1870, elaborated and propounded the orientation theory. It was not, however, until 1892, when Ewald made some exact experiments, that a definite law of the production of the nystagmus of the semicircular canals was discovered. Ewald took pigeons and blocked the canals with wax at a point about opposite the ampulla. Then into the bony wall close to this blocking point, between it and the ampulla, he introduced a movable piston, the end of which played upon the endolymphaticum. By squeezing an air bulb attached to this piston he pressed it against the endolymphaticum and produced a movement of the endolymph in the direction of the ampulla and hair cells; by a suction movement of the piston backward a reverse movement of the endolymph took place. Ewald discovered that the nystagmus produced by these experiments was always in the direction contrary to the movement of the endolymph. The direction of the nystagmus is indicated by the direction of the short, quick movement (it being the first movement); the slow movement of recovery being, of course, in the opposite direction. Thus the law is: *The nystagmus is always in the direction opposite to the movement of the endolymph.*

Barany devised a series of tests whereby the movement of the endolymph is produced by turning the patient in a revolving chair. If the patient, sitting upright with his head erect, is revolved, let us say to the right, the horizontal semicircular canals lying in the plane which is acted upon by the centrifugal force, has a resulting movement of the endolymph. The endolymph of the anterior vertical and posterior vertical canals (lying at right angles to the plane of this force) is unaffected by it. The endolymph of the horizontal canals, when the patient is being turned, following the law of a body at rest, remains at rest unless acted upon by some external force, is contrary to the direction of turning and the nystagmus is in the direction of turning.

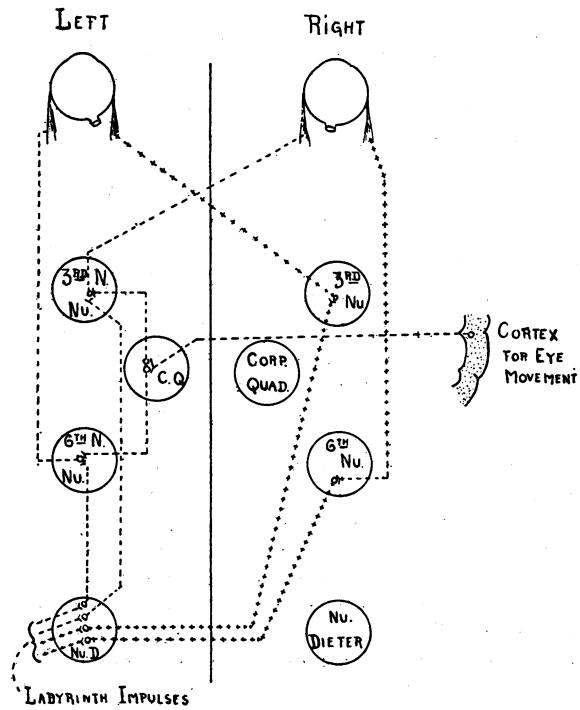
However, as it is impossible to measure the nystagmus while the patient is being revolved, it is disregarded. When the patient is brought to a stop after being turned ten times, the endolymph, following the law of a body in motion remaining in motion, is circulating in the direction of the revolving—to the right. The nystagmus is now to the left, and the patient being stationary the duration of the reflex movement is timed with a stop watch from the instant of stopping the revolutions to the time of cessation of the reflex movement. When the horizontal canal is tested the nystagmus resulting is a horizontal nystagmus; that is, the movements are horizontal. By bringing the patient's chin down, and flexing the head forward at right angles, the anterior vertical canals are brought into the plane of the centrifugal force, and the endolymphatic movements now take place in them; the horizontal and posterior vertical canals being unaffected. The nystagmus from the anterior vertical canal is rotary, corresponding to the wheel-like motion of the eye, and, in direction, follows the law of being contrary to the direction of endolymphatic movement. By bending the patient's head sharply over either shoulder and revolving him in a similar manner, the posterior vertical canals receive the centrifugal impact and the resulting reflex is a vertical, up and down nystagmus. By successively changing the position of the head in this way all the canals may be tested, and the results show that *each canal produces the movement in its own plane:* the horizontal canals, lying in a horizontal plane, produce a horizontal nystagmus; the anterior verticals, lying in a plane at once vertical and at right angles to the antero-posterior axis of the eye, produce a rotary or wheel-like nystagmus; the posterior vertical canals, lying in the sagittal plane, produce a vertical up and down nystagmus. This gives us our clew to the physiology of the movements. Standing erect, and revolving to the right on the long axis of our body, our eyes move quickly in a horizontal direction to the right and fix an object; the revolving movement of the entire body carries them soon beyond the fixing point. This corresponds to the slow reverse movement. The eyes then jump to the right again to fix, and thus the nystagmus-like movement keeps up. This movement is produced reflexly, when the revolution is rapid, by the movement of the endolymph in the horizontal, semicircular canals. A similar movement of the eyes takes place in an action like a somersault in a vertical direction, and is produced by endolymphatic movement in the posterior vertical canals which lie in the sagittal plane. The anterior vertical canals on being brought into play in an action corresponding to a boy turning a "cart-wheel," the resulting nystagmus is rotary, the reflex corresponding to wheel movements of the eyes when looking up, and to the right or left; and down and to the right or left (Donders listing), which is the position the eyes would assume in an attempt to fix in a movement of this kind.

Through these movements of the endolymph, too, we perceive our relative position in space, particularly in the dark, when the eyes furnish no added information. For example, in waking up at night in a sleeping-car berth, we know at once when the brakes are applied, or when the train is increasing its speed through this organ. In birds, with their sensitive orientation through the three dimensions of space, we find the canals relatively enormously larger and better developed. In man their function is retrogressive, and the part they play in orientation is comparatively insignificant.

If the eyes attempt to fix a revolving object a nystagmus results, which is designated as optical nystagmus. It is best seen, perhaps, in persons looking out of the window of a rapidly moving train. It is seen resulting from retinal irritation in albinos and in miners. It can be seen in the experiment of taking a cylinder which revolves on its long axis, and printing stripes on the curved surface running parallel with its long axis. The patient is told to look at the cylinder, and unconsciously fixes his regard on the stripes. When it is revolved slowly the optical nystagmus is seen. If the patient stands with the line of regard at right angles to the stripes the nystagmus is vertical; if it is parallel the nystagmus is horizontal. This nystagmus is stronger than that originating in the semicircular canals; and in testing the latter, the optical nystagmus is eliminated by placing opaque spectacles on the patient, and while he is being turned he is instructed to keep his gaze directly into the center of the opaque glasses, or "blind specks," as they are conveniently called. The normal duration of the nystagmus, after being turned ten times in one direction, with the same velocity, and with blind specks on the patient, varies from twenty-five seconds to two minutes; the average is about forty-five seconds for the horizontal and twenty-two seconds for the vertical and rotary. Without blind specks the nystagmus lasts only fifteen to twenty seconds. Rapid turning increases the duration. Patients of high nervous organizations have a longer reaction, and in neuresthenics we find a maximum duration. The practical point in the examination is the comparison of the duration of both sides. It has been found by repeated experiments that two-thirds of a nystagmus, let us say, to the right is produced by the right labyrinth, the remaining third coming from impulses from the left. Contrarywise two-thirds of the nystagmus to the left comes from the left labyrinth. If now we have a patient, who when turned to produce a right nystagmus, reacts with a shortened duration of it, let us say fifteen seconds, and when turned to produce a left nystagmus reacts with double the duration, or thirty seconds, we surmise a destruction of the right labyrinth; for both series of revolutions show the absence of impulses from the right side. This may be expressed graphically in the diagram:



The tract of the nerve impulses is from the canals through the vestibular nerve to Deiters nucleus. From here axones are sent to the nuclei of the eye muscles, from there they pass to the eye muscles direct. Those axones for the quick movement pass to the nuclei on the same side; those for the slow movement cross over to the nuclei of the opposite side. The motor ocular nuclei receive impulses via the corpora quadnigemina from the cortical eye centers on the opposite side. This is perhaps better explained by the diagram:



Scheme of tracts for horizontal nystagmus to the left side produced by the left ear.
— — — — tracts of quick movement.
+ + + + tracts of slow movement.

In testing a person who, by occupation, is constantly revolving in one direction, the normal reactions will not hold. Ballet dancers who whirl only in one direction, which is the rule, show great difference in the resulting nystagmus when turned to the right and left. When turned in the direction in which they are used to revolving the nystagmus is very small, as a consequence of their continual practice, and lessening of the reflex.

The cortical impulses from the opposite side, reinforce the quick movements and the result is that the nystagmus is always stronger when the patient is told to look in the direction of the quick movement—the direction of the nystagmus. It is in this position that the duration of the nystagmus is best tested.

If the patient has a spontaneous nystagmus in looking strongly to the right or left, a point in the arc of rotation is selected in which it is not present, and with the eye in this position the tests are made. Barany has devised an instrument to facilitate this, which consists merely of a head band with a movable ball-tipped rod, which can be swung and fixed to any point in the visual field. If the patient has a spontaneous nystagmus in looking strongly to the left, the rod is swung in the left field. The patient is told to regard the small ball at the tip as it is moved to the left. When a point is reached that produces the nystagmus, the arm is moved slightly back again to a point which does not elicit it, and the patient is observed carefully to see that no spontaneous nystagmus is present. He is then turned with the instrument in this position on his head, and as soon as the revolving ceases he is told to fix his regard upon the ball when the duration of nystagmus is noted.

As we have diverted to explain the physiology of the nystagmus, we will now return to the technic of the test. A revolving chair is used, which is best fitted with a stout iron rod running vertically up from the back of the revolving seat, six inches above the height of the average person's head, when he is sitting upright upon the chair. The surgeon is provided with a stop watch. If the light is not good he had better have his head mirror adjusted to throw an artificial light into the eye. The patient, for testing the horizontal canals, is told to sit erect with his head erect in the line of the axis of turning. The blind specs are adjusted, and he is told to look directly into them while being turned. He may hold the seat of the chair to steady himself. The iron rod is now grasped and the patient turned ten times, without accelerating or diminishing the speed. As soon as the turning is stopped the surgeon starts the stop watch. If he is being turned to the right, which produces on cessation of the movement, a nystagmus to left, the patient is told to look strongly to the left that the full duration and strengh of the nystagmus may be brought out. When the nystagmus ceases the surgeon stops the stop watch, and the duration is noted. The patient is then turned under the same conditions in the opposite direction; as the nystagmus will be opposite, he is told to look in the opposite direction when the revolving is finished, and the duration of this nystagmus is noted and compared with that of the previous test. It requires a little practice to say accurately when the nystagmus stops. This is because it gets slower, with longer intervals betwen the jerks as it fades away. With practice, however, the surgeon soon chooses the same relative time of cessation. By bending the head sharply ninety degrees forward the anterior vertical canals may be tested; or bending it ninety degrees over the shoulder the posterior vertical canals react. The reaction of one canal, usually the horizontal, is all that is practically required; as the finding in one holds for all three. The turning tests are used in conjunction with, or supplement another simpler method—the *caloric* nystagmus.

If you take any vessel containing a fluid, and chill one side of it, the fluid on the chilled side following the well-known physical law sinks and a current is established. Contrary-wise, if you heat one side a current in the opposite direction is established. This holds in the semicircular canals, the narrowness of which causes them to respond quicker than is the case in a relatively wider vessel. The anterior vertical canal lying just behind the promotory, and in the vertical plane allowing the rise and fall of the endolymph, responds to heat and cold even applied no closer than the membrana tympani. The results is, if cold is used upon the left side the endolymph sinks, a current to the left is established, and the nystagmus, contrary to the current, is to the right and rotary in character, as produced by this canal. The contrary holds if heat is applied. On the right side, cold produces a nystagmus to the left; heat to the right. A convenient formula to remember the reaction is: the nystagmus runs away from the cold to the opposite side.

The test is made by simply playing a small stream of cold water, or warm water, gently and slowly upon the drum, or into the middle ear for five minutes, with an irrigating syringe and a canula. If the labyrinth is normal the patient responds with a rotary nystagmus. If it is destroyed, no reaction is produced. The water must be colder than the temperature of the body. The ordinary tap water is usually the proper temperature to be used. If the patient has fever this must be remembered and a higher temperature of water used if hot water is employed. The warmest temperature of water that can be used in the ear is 48° C. It takes a little time for the nystagmus to be produced in this way—it usually commences about the termination of the syringing. The reaction takes place very promptly in patients who have had the radical mastoid operation performed, as the water is brought into immediate contact with the wall of the canal. If the drum is intact and is very thick, a longer period of chilling is necessary to get the reaction. In some cases, when a mass of cholesteatoma or polyps fill the middle ear, the caloric change may not reach the canal, and no reaction would result, in which event we would have to rely upon the turning tests alone. The rotary form of nystagmus is accompanied by much more nausea than the other forms. This

explains the fact which has fallen within the experience of all aurists that some patients become dizzy and nauseated when their ears are syringed out repeatedly—as for the removal of cerumen—and which always accompanied the hot air treatment for oto-sclerosis.

Quite a few cases have been observed in suppurative processes of the middle ear, when the bony wall of a canal has been disintegrated, but the endolymphaticum remains intact, and the labyrinth responds to the turning and caloric tests. This condition is diagnosed by the compression and rarefaction of air in the middle ear. A Politzer bag is used with a tip that fits accurately and tightly into the external auditory canal. When the bag is forcibly compressed the air is forced through the opening of the bony wall of the semicircular canal and against the lymphaticum, producing a current of the endolymph and the corresponding nystagmus. Rarefaction of the air produces nystagmus in the opposite direction. This is known as the *fistula test.* The direction and character of the nystagmus will of course depend upon the site of the opening. the canal involved.

It has been known for many years that the galvanic current with the poles on each ear, and a current as small as two to four milliampers, produced a nystagmus. This has been investigated, and it is found that with a current from fifteen to twenty-five milliampers and one pole held in the hand, the kathode on the right ear gives rotary nystagmus to the right; the anode on the right ear gives rotary nystagmus to the left. The effect of the current is on the nerve proper. It reacts to the galvanic tests when the labyrinth is destroyed. The normal tonus of each ear balances the other. The kathode heightens the excitability—katelectrotonus; the anode lessens it—anelectrotonus. Putting the kathode to the right ear heightens the excitability on that side, and gives us the corresponding rotary nystagmus to right; the anode lessens the normal tonus, swings the balance to the other ear and gives rotary nystagmus to the left. Inasmuch as the effect is upon the nerve proper, this test is not used in the practical surgical examination, but may be useful in locating a lesion.

Another phenomenon may be mentioned, although it is not employed practically on account of the intricate optical apparatus necessary for measuring it, is the tilting of the vertical meridian of the eyes in lateral movements of the head. If we look straight ahead, and tilt our heads to either side, the vertical meridian of the cornea remains upright during the movement. Barany found in patients with destroyed labyrinths 4 to 16 degrees tilting of the vertical meridian, when the head was rolled over 60 degrees; in deaf mutes the tilting was 1-8 degrees in the same tests.

Intracranial lesions affecting the nystagmus tract give rise to a spontaneous nystagmus. It is often seen in disseminated sclerosis, hereditary ataxia, meningitis and meningeal hemorrhage, cerebellar abscess and tumors, occasionally in sinus thrombosis, and a number of affections of the brain. Excepting in cerebellar abscess and in sinus thrombosis, there is not apt to be any coincident ear discharge to confuse the surgeon as to whether the nystagmus is central or labyrinthian in origin. The majority of cerebellar abscesses come from a suppurating labyrinth. The infection passing through the channel of the internal meatus and in these cases the labyrinth is, of course, involved. In a case of suspected cerebellar abscess, with a chronic suppuration of one ear, a nystagmus to the same side, the tests showing no irritability of the labyrinth on that side, we are safe in assuming that the nystagmus comes from cerebellar irritation, because the labyrinth producing it is destroyed. Intracranial nystagmus is continuous; that originating in the ear is intermittent. Sudden destruction of one labyrinth gives a continuous nystagmus to the opposite side, from the sudden removal of the balanced tonus. The nystagmus in this case diminishes, and after a time disappears. After a labyrinth operation the balance is regained in about four days; in pathological cases the disease keeps up the irritation and a much longer period is required, but the tendency of these cases of spontaneous nystagmus is to diminish, as distinguished from the intracranial variety. Cerebellar growths have no accompanying ear discharge as a rule, and the ataxic and other nerve symptoms enable the origin of the nystagmus to be placed. Nystagmus only results from sinus thrombosis late in the case, when abscesses of the brain or cerebellum have been produced, or a meningitis has set in. At this period it is of no practical value to ascertain the origin of the nystagmus, as the treatment would be unaffected by the findings. In the great run of cases, consequently, intracranial nystagmus will not lead to confusion in drawing conclusions.

The routine of making tests in a suspected case, when dizziness is complained of in a patient with ear symptoms—dizziness should always make us suspect labyrinth involvement—is first to use the cold water test. If a rotary nystagmus to the opposite side results we know that the labyrinth is functionating. In some cases when the membranous labyrinth is not involved the organ may functionate, but still have an opening in its bony wall. So we proceed to the fistula test. If compression of air gives a resulting nystagmus, an opening is present, or we have heightened irritability from lues. If there is a resulting nystagmus from the caloric test, and none from the fistula test, we conclude that the organ is intact and not involved in the suppurative process. If we have abnormal irritability from syphilis, the compression of air only gives a faint, small amount of nystagmus—with a fistula present there is a strong reaction to the test. If the cold water gives no responsive nystagmus, we conclude that the labyrinth is destroyed, or that some mass like cholesteatoma or polypi interfere with the test. We now try the turning tests. If the nystagmus resulting is shortened, and only half as long in duration in producing nystagmus to the affected side as that produced to the opposite side we must con-

clude that the labyrinth is destroyed; if the turning tests show a normal reaction, an intervening mass must have been present in the caloric test to prevent the action of the cold water on the canal. The destruction of the labyrinth would of course be confirmed by the functional tests of hearing. Caution must be exercised, however, to be sure that the good ear is safely cut out, for the ordinary method of sticking the finger in the meatus of the good ear does not prevent the bone conduction of sound from the normal side to it. Barany found that many ears which had been operated on, and the labyrinth absolutely destroyed, afterwards had apparently a little hearing on that side until he devised a special instrument, which successfully eliminated the good ear in testing the other, and he then corroborated what he expected to find: absolute deafness. He also found absolute deafness in destroyed labyrinths before operation, in which the tuning fork, speaking and speaking-tube tests would indicate a slight amount of function to be present.

The nystagmus is accompanied by a few symptoms, such as the apparent falling of objects, the patient's sensation of falling, his effort to maintain his equilibrium; nausea and sometimes vomiting. In highly sensitive patients we may have a sensation of color or darkness, pallor, sweating, trembling, and, rarely, loss of consciousness. These quickly pass off. The optical sensation of falling objects takes place during the slow movement of the nystagmus. If we take, for example, a rotary nystagmus to the right, the sensation occurring in the slow movement to the left, objects will rotate and fall to the right side. The sensation in regard to objects is stronger when the patient looks in the direction of the nystagmus, which increases the nystagmus. In some patients the optical sensation takes place in both the slow and rapid movement, and in these cases objects will oscillate instead of appearing to fall. The patient has the sensation himself of falling in the direction of the nystagmus; he throws himself in the contrary direction to balance himself, and thus actually falls in the opposite direction. The reaction of falling is in the same plane as the nystagmus and opposite to it; that is, in a horizontal nystagmus the patient falls or throws himself to the right or left, according to whether the nystagmus is left or right; in a vertical he goes forward or backward; and in the rotary he tends to sidewise rotation in the fall.

The number of cases of suppurative processes in the ear, in which the labyrinth is involved, is larger than we would at first suppose. The subject is too new for accurate statistics to be gathered and the percentage stated at present. In the Allgemeinen Krankenhaus in Vienna, the tests I have described are in the routine of the functional tests performed, and in that institution two or three labyrinth cases are continually in the wards. Some months ago they had a record of ninety cases. This in itself is sufficient to emphasize the fact that when searched for they are found more frequently than the aurist would suppose; and they explain the fact that every once in a while the aurist found a case in which after doing a radical mastoid operation, healing was long delayed; the labyrinth was involved and not drained.

In every case in which the labyrinth is involved in a suppurative middle ear process, it should be opened and drained at the time of the radical operation. If a fistula is found, the same operation is indicated, excepting in a case where the patient has very bad hearing in the other ear. In this event chances might be taken, in order to preserve his hearing, and, after searching for the opening in the canal wall, its edges may be curretted, and reliance placed upon it being sufficient for drainage. It is distinctly dangerous to do a mastoid operation when the labyrinth has recently become involved, without opening and draining the labyrinth. In these cases the inflammatory capsule is not sufficiently developed to prevent the exascerbation of the labyrinthitis by the trauma of the operation extending through the internal meatus and setting up a meningitis. Undoubtedly many cases of meningitis following mastoid operations were due to this process. Even in older cases of labyrinth involvement this danger is present, and consequently to obviate danger and to prevent a long drawn out process of healing, it should be radically treated at the time of the mastoid operation.

THE LEUKEMIAS AND ALLIED DISEASES.*

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It is my purpose to consider a group of diseases not very often encountered, but one of peculiar interest, both from the pathological and the clinical standpoint. The etiology of this group is still a matter of doubt, though more and more observers are granting the point that we are dealing with clinical malignancy and possibly pathological malignancy. To call a certain group of diseases malignant does not, of course, help in the ultimate solution of its etiology since the causes of cancer are still unknown; but to grant that they are malignant helps us at least in a classification, prognosis and treatment.

A list of the conditions referred to recalls at once malignant disease with gradual transitions to the ordinary sarcoma. This list comprises the following diseases: Lymphosarcoma, leukosarcoma, chronic lymphocytic leukemia, chloroma, Hodgkins' disease, and other forms of pseudo leukemia, chronic myelocytic leukemia, myeloma. I shall attempt to offer proof that they are essentially malignant. Some show in their course an increase of various white cells in the blood, and it is this impression of increased leukocytes that is dominant in the minds of most physicians. I shall attempt to show that the importance of the blood picture is over-accentuated. I shall also try to show that the ordinarily accepted blood picture is not absolutely

*Read before the Cooper College Science Club.